

UTILITY
PATENT APPLICATION
TRANSMITTAL

Only for new nonprovisional applications under 37 CFR 1.53(b)

Attorney Docket No.

P00,0514

First Named Inventor or Application Identifier

Wolfgang Renz et al.

Express Mail Label No: # EL497037934US

ADDRESS TO: Assistant Commissioner for Patents
Box Patent Application
Washington, DC 20231

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. ☒ Specification [Total Pages 10]
2. ☒ Drawing(s) (35USC 113) [Total Pages 3]
3. ☒ Declaration and Power of Attorney [Total Pages 2]
 - a. ☒ Newly executed declaration (Original copy)
 - b. ☐ Copy from prior application (37CFR 1.63(d))
(for continuation/divisional with Box 14 completed)
 - [Note Box 4 Below]
 - i. ☐ **DELETION OF INVENTOR(S)**
Signed statement attached deleting
Inventor(s) named in the prior application,
see 37 CFR 1.63(d)(2) and 1.33(b).
4. ☐ Incorporation By Reference (usable if Box 3b is checked)
The entire disclosure of the prior application, from which a
copy of the oath or declaration is supplied under Box 3b,
is considered as being part of the disclosure of the
accompanying application and is hereby incorporated by
reference therein.

ACCOMPANYING APPLICATION PARTS

5. ☒ Assignment Papers (cover sheet & documentation)
Siemens Aktiengesellschaft
6. ☐ Letter under 37 CFR 1.41(c).
7. ☐ English Translation Document (if applicable)
8. ☐ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
9. ☐ Preliminary Amendment
10. ☒ Return Receipt Postcard (MPEP 503)
(Should be specifically itemized)
11. ☐ Small Entity ☐ Statement filed in prior application,
Statement(s) Status still proper and desired
12. ☒ Certified Copy of Priority Document(s) German
Application No. 199 14 989.5 filed April 1, 1999
13. ☐ Other:

14. If a CONTINUING APPLICATION check appropriate box and supply the requisite information:

☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) ☐ of prior application No: /

CLAIMS AS FILED

(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) BASIC FEE \$690.00
TOTAL CLAIMS 20	13			
INDEPENDENT CLAIMS 3	1			
ANY MULTIPLE DEPENDENT CLAIMS? (YES (X) NO)				
			TOTAL FILING FEE ->	\$690.00

☒ The Commissioner is hereby authorized to charge any additional fees which may be required in connection with this application, or credit any overpayment to ACCOUNT NO. 08-2290. A duplicate copy of this sheet is enclosed.

☒ A check in the amount of \$ 690.00 to cover the filing fee is enclosed.

15. CORRESPONDENCE ADDRESS

HILL & SIMPSON
A Professional Corporation
233 South Wacker Drive - 8th Floor Sears Tower
Chicago, Illinois 60606
Telephone (312) 876-0200 - Fax (312) 876-0898

SIGNATURE:
491/899:1190
U-11

SK Noll #28,982

DATE: March 31, 2000

1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320	2330	2340	2350	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540	2550	2560	2570	2580	2590	2600	2610	2620	2630	2640	2650	2660	2670	2680	2690	2700	2710	2720	2730	2740	2750	2760	2770	2780	2790	2800	2810	2820	2830	2840	2850	2860	2870	2880	2890	2900	2910	2920	2930	2940	2950	2960	2970	2980	2990	3000	3010	3020	3030	3040	3050	3060	3070	3080	3090	3100	3110	3120	3130	3140	3150	3160	3170	3180	3190	3200	3210	3220	3230	3240	3250	3260	3270	3280	3290	3300	3310	3320	3330	3340	3350	3360	3370	3380	3390	3400	3410	3420	3430	3440	3450	3460	3470	3480	3490	3500	3510	3520	3530	3540	3550	3560	3570	3580	3590	3600	3610	3620	3630	3640	3650	3660	3670	3680	3690	3700	3710	3720	3730	3740	3750	3760	3770	3780	3790	3800	3810	3820	3830	3840	3850	3860	3870	3880	3890	3900	3910	3920	3930	3940	3950	3960	3970	3980	3990	4000	4010	4020	4030	4040	4050	4060	4070	4080	4090	4100	4110	4120	4130	4140	4150	4160	4170	4180	4190	4200	4210	4220	4230	4240	4250	4260	4270	4280	4290	4300	4310	4320	4330	4340	4350	4360	4370	4380	4390	4400	4410	4420	4430	4440	4450	4460	4470	4480	4490	4500	4510	4520	4530	4540	4550	4560	4570	4580	4590	4600	4610	4620	4630	4640	4650	4660	4670	4680	4690	4700	4710	4720	4730	4740	4750	4760	4770	4780	4790	4800	4810	4820	4830	4840	4850	4860	4870	4880	4890	4900	4910	4920	4930	4940	4950	4960	4970	4980	4990	5000	5010	5020	5030	5040	5050	5060	5070	5080	5090	5100	5110	5120	5130	5140	5150	5160	5170	5180	5190	5200	5210	5220	5230	5240	5250	5260	5270	5280	5290	5300	5310	5320	5330	5340	5350	5360	5370	5380	5390	5400	5410	5420	5430	5440	5450	5460	5470	5480	5490	5500	5510	5520	5530	5540	5550	5560	5570	5580	5590	5600	5610	5620	5630	5640	5650	5660	5670	5680	5690	5700	5710	5720	5730	5740	5750	5760	5770	5780	5790	5800	5810	5820	5830	5840	5850	5860	5870	5880	5890	5900	5910	5920	5930	5940	5950	5960	5970	5980	5990	6000	6010	6020	6030	6040	6050	6060	6070	6080	6090	6100	6110	6120	6130	6140	6150	6160	6170	6180	6190	6200	6210	6220	6230	6240	6250	6260	6270	6280	6290	6300	6310	6320	6330	6340	6350	6360	6370	6380	6390	6400	6410	6420	6430	6440
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------

Date of Deposit: March 31, 2000

Proposed Patent Application for WOLFGANG RENZ and MARKUS VESTER
entitled "MAGNETIC RESONANCE ANTENNA", consisting of specification, claims, 3
sheets of informal drawings, Certified Copy of German Application 19914989.5,
Assignment, Government Filing Fee, Attorney Docket No. P00,0514

Name of person mailing application

SPECIFICATION

TITLE

"MAGNETIC RESONANCE ANTENNA"

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a magnetic resonance antenna for magnetic resonance systems with a vertical basic field, the magnetic resonance antenna being of the type having a number of antenna elements that extend substantially radially from an inner element to at least one outer element, relative to a center axis, the antenna elements being at least magnetically coupled with one another.

DESCRIPTION OF THE PRIOR ART

A magnetic resonance antenna of the above type is known from United States Patent No 5,153,517. This magnetic resonance antenna has four antenna elements that are driven in pairs with 90° phase quadrature.

So-called birdcage resonators are known for magnetic resonance systems with an axial basic field. These have a number of antenna elements that are circularly arranged around a center axis and that extend parallel to the center axis. These antenna elements, at their ends, are connected to one another via ring-shaped connecting elements in an electrically conducting manner.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a magnetic resonance antenna for magnetic resonance systems with a vertical basic field, with which a homogeneous circularly polarized magnetic field can be generated in

a simple manner.

The above object is achieved in accordance with the principals of the present invention in a magnetic resonance antenna formed by a number of antenna elements which proceed substantially radially from an inner element beginning to at least one outer element and, relative to a center axis, the antenna elements being at least magnetically coupled with one another, and wherein the number of antenna elements is at least five.

The antenna elements are coupled with one another at least via their magnetic field. In addition, they can also be coupled with one another via connecting elements at the element beginnings and/or element ends. Such an electrically conducting connection is preferably effected via a connecting element that is fashioned in a ring-shaped manner. Alternatively, the element beginnings and/or element ends can be individually connected to a grounding plane instead of being connected among each other with connecting elements.

Capacitors can be arranged in all antenna elements and/or connecting elements in order to adapt the magnetic resonance antenna to the desired operating frequency.

Regardless of the type of coupling, what is important in both cases is that the antenna elements are coupled with one another such that the magnetic field, which is generated by them, is circularly polarized.

In the most simple case, the antenna elements can each have one element beginning and one element end. As warranted, however the antenna elements can be split toward the outside, i.e. they can have at least two element ends.

The geometry of the magnetic resonance antenna can be even. The construction of the magnetic resonance antenna is particularly simple in this case. When the element beginnings define an element beginning plane and the element ends a element end plane, and when the element beginning plane and the element end plane extend parallel to one another and are

offset to one another, a particularly homogenous magnetic field results in the area of the center axis. Preferably, the antenna elements are fashioned linear in this case.

The antenna elements each exhibit a line direction, whose extrapolation cuts the center axis in a common intersecting point. The magnetic field generated by means of the magnetic resonance antenna is more homogenous when the element beginning plane and the element end plane extend parallel to a grounding plate. It is particularly homogenous when the intersecting point is situated in the grounding plate.

When the number of antenna elements can be divided by four, the coupling-in and coupling-out of two currents that are phase-shifted by 90° is particularly simple.

DESCRIPTION OF THE DRAWINGS

Figure 1 is a plane view of a first embodiment of a magnetic resonance antenna constructed in accordance with the principals of the present invention.

Figure 2 is a plane view of a second embodiment of a magnetic resonance antenna constructed in accordance with the principals of the present invention.

Figure 3 is a plane view of a third embodiment of a magnetic resonance antenna constructed in accordance with the principals of the present invention.

Figure 4 is a plane view of a fourth embodiment of a magnetic resonance antenna constructed in accordance with the principals of the present invention.

Figure 5 is a prospective view of a magnetic resonance antenna constructed in accordance with principals of the present invention.

Figure 6 is a side view of the fourth embodiment of the magnetic resonance antenna, shown in Figure 4.

Figure 7 is a side view of the first embodiment of the magnetic resonance antenna, shown in Figure 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 shows the basic shape of an inventive magnetic resonance antenna. It has at least five (eight according to Figure 1) antenna elements 1. The antenna elements 1 extend radially from an inner element bar beginning 3 to an outer element end with respect to a center axis 2. According to Figure 1, the element beginnings 3 are connected to one another in an electrically conducting manner via an inner connecting element 5, and the element ends 4 are connected to one another in an electrically conducting manner via an outer connecting element 6. According to Figure 1, both connecting elements 5, 6 are fashioned in a ring-shaped manner. Therefore, the antenna elements 1 not only are magnetically coupled with one another but also are electrically coupled. The magnetic resonance antenna exhibits a cyclic symmetry from antenna element 1 to antenna element 1.

The magnetic resonance antenna has two connections 7, which, offset by 90° , are arranged at the outer connecting element 6. At these two connections 7, two currents that are phase-shifted by 90° can be alternatively coupled or coupled out with a magnetic resonance frequency f . As a result, a circularly polarized magnetic field can be alternatively emitted or received with the magnetic resonance antenna according to Figure 1. The magnetic resonance frequency usually lies between 8 MHz and 100 MHz. The currents and magnetic fields that flow at a specific point in time are indicated in Figure 1 by means of the normal symbols.

According to Figure 1, capacitors 8 are arranged in the outer connecting element 6. Alternatively, the capacitors 8 could be arranged in the inner connecting element 5 or in the antenna elements 1.

Figures 2 through 5 show modifications of the basic fashioning according to Figure 1. Identical elements are thereby provided with identical reference numbers. The capacitors 8 contained in the antenna elements 1 and/or in the connecting elements 5, 6 are not shown in the Figures 2 through 5 for simplification.

According to Figures 2 and 3, the element ends 4 are connected to one another in an electrically conducting manner via the outer connecting element 6. In contrast thereto, the element beginnings 3 are directly connected to one another in an electrically conducting manner according to Figure 2 and, according to Figure 3, are grounded. Further, in the embodiment of Figure 2, the antenna elements 1 are split toward the outside, i.e. they respectively have two element ends 4. In the embodiment of Figure 4, the element beginnings 3 are connected to one another in an electrically conducting manner via the inner connecting element 5 and the element ends 4 are grounded.

In the embodiment according to Figure 5, the antenna elements 1 are only magnetically coupled with one another. According to Figure 5, the element beginnings 3 and the element ends 4 are grounded.

Figure 6 shows the embodiment of the magnetic resonance antenna according to Figure 4 in profile from the side. The magnetic resonance antenna is planarly constructed. It is also possible (as explained in the following in connection with Figure 7) that the element beginnings 3 define an element beginning plane 9 and that the element ends 4 define an element end plane 10, the element beginning plane 9 and the element end plane 10 extending parallel to another, and being offset from one another.

Figure 7 shows the basic fashioning of the magnetic resonance antenna according to Figure 1 from the side. According to Figure 7, the antenna element 1 exhibit a line direction. The extrapolation of the line direction intersects the center axis 2 in a common intersecting point 11. The intersecting point 11 is situated in a grounding plate 12, which extends

parallel to the element beginning plane 9 and to the element end plane 10. The slope of the antenna elements 1 relative to the grounding plate 12 should not exceed 45° . Otherwise, the slope can be selected as required.

The inventive magnetic resonance antenna exhibits high efficiency given the generation and the reception of a circularly polarized magnetic field.

The number of antenna elements 1 can be selected as required as long as it is equal to or exceeds five. It is particularly beneficial, however, when the number can be divided by four, namely 8, 12, 16 etc.. Then, the coupling-in and coupling-out of two currents, which are phase-shifted by 90° , is especially simple for generating or scanning a circularly polarized magnetic field.

The inventive magnetic resonance antenna can be utilized in magnetic resonance systems with a vertical basic field in order to generate or receive a high-frequency magnetic field that is transverse relative to the vertical basic field. Thereby, it is particularly advantageous that crossing (overlapping) antenna element do not occur in the basic design and thus will not come into contact with one another, so that special measures do not have to be undertaken to isolate the elements from one another.

Although modifications and changes may be suggested by those skilled in the art, it is the intention of the inventors to embody within the patent warranted hereon all changes and modifications as reasonably and properly come within the scope of their contribution to the art.

WE CLAIM AS OUR INVENTION:

1. A magnetic resonance antenna comprising:
a plurality of antenna elements, each antenna having an element beginning and an element end;
said antenna elements being disposed radially relative to a center axis so as to proceed outwardly from the respective element beginnings to the respective element ends;
said antenna elements being at least magnetically coupled with each other; and
said plurality being at least five.
2. A magnetic resonance antenna as claimed in claim 1, wherein the respective element beginnings and the respective element ends are connected to ground.
3. A magnetic resonance antenna as claimed in claim 1 wherein said antenna elements are electrically coupled to each other.
4. A magnetic resonance antenna as claimed in claim 3 wherein the respective element beginnings are electrically connected to each other via a ring-shaped connecting element.
5. A magnetic resonance antenna as claimed in claim 3 wherein the respective element ends are electrically connected to each other via a ring-shaped connecting element.
6. A magnetic resonance antenna as claimed in claim 3 wherein the respective element beginnings are electrically connected to each other via a first ring-shaped connecting element and wherein the respective

element ends are electrically connected to each other via a second ring-shaped connecting element.

7. A magnetic resonance antenna as claimed in claim 1, wherein each of said antenna elements has two branching element ends.

8. A magnetic resonance antenna as claimed in claim 1 wherein the respective element beginnings define an element beginning plane and wherein the respective element ends defines an element end plane, and wherein said element beginning plane and said element end plane are parallel to and spaced from each other.

9. A magnetic resonance antenna as claimed in claim 8 wherein the respective antenna elements are linear.

10. A magnetic resonance antenna as claimed in claim 8 wherein the respective antenna elements define respective line directions, said line directions intersecting said center axis at a common point.

11. A magnetic resonance antenna as claimed in claim 10 further comprising a grounding plate disposed parallel to said element beginning plane and said element end plane, and said common point being disposed in said grounding plate.

12. A magnetic resonance antenna as claimed in claim 8 further comprising a grounding plate disposed parallel to said element beginning plane and said element end plane.

13. A magnetic resonance antenna as claimed in claim 1 wherein said plurality is divisible for four.

Abstract

A magnetic resonance antenna has at least five antenna elements, each of, which extends essentially radially from an inner element beginning to at least one outer element end with respect to a center axis. The antenna elements are at least magnetically coupled with one another.

Reference character list

1	antenna bars
2	center axis
3	bar beginnings
4	bar ends
5, 6	connecting elements
7	connections
8	capacitors
9, 10	planes
11	intersecting point
12	grounding plate
f, f0	frequencies

$\frac{1}{3}$

FIG 1

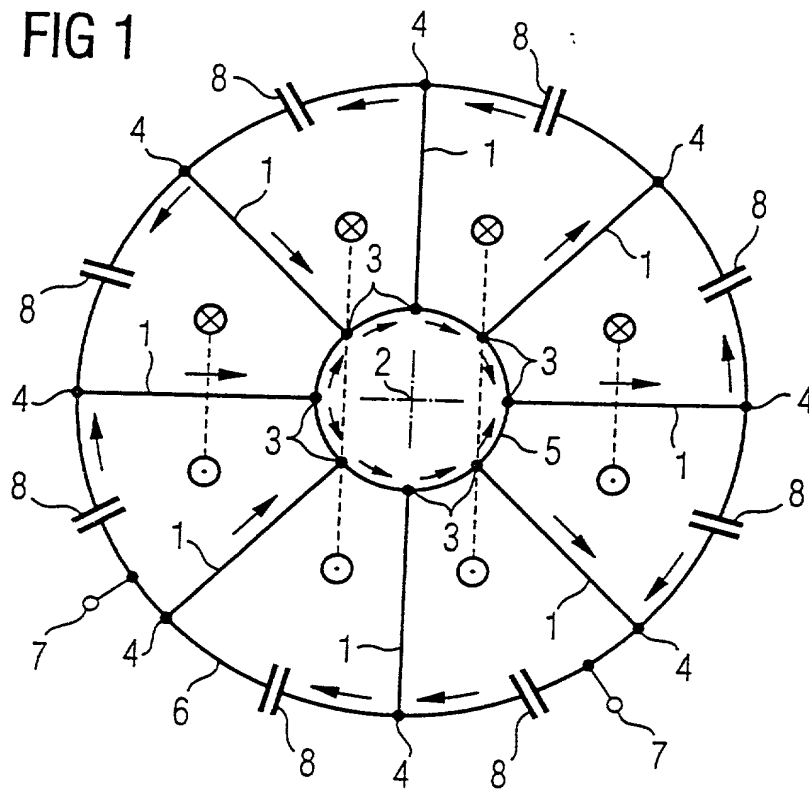


FIG 2

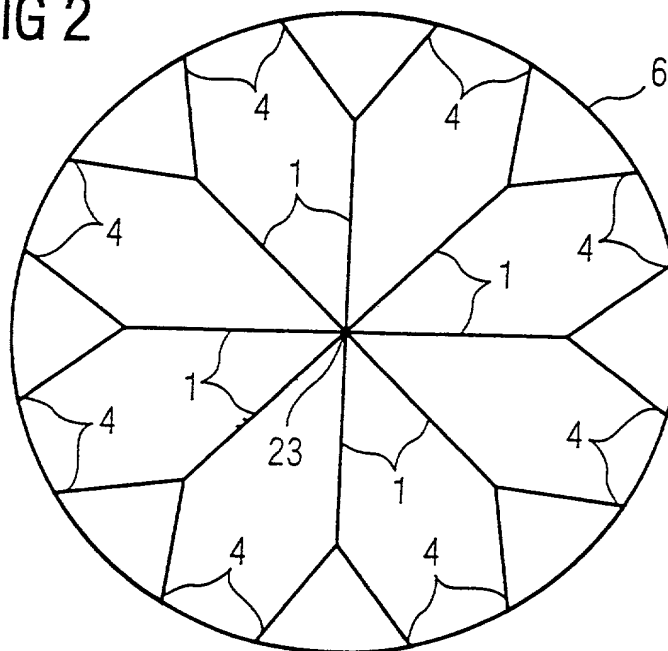


FIG 3

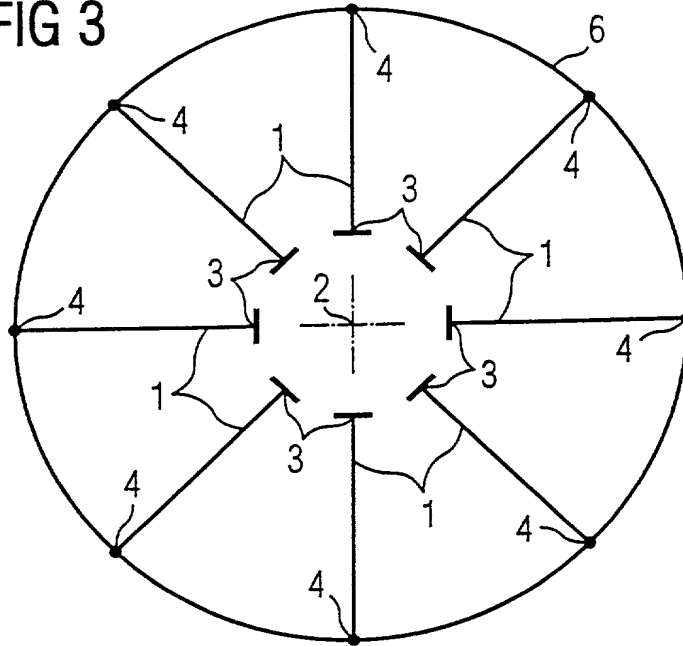


FIG 4

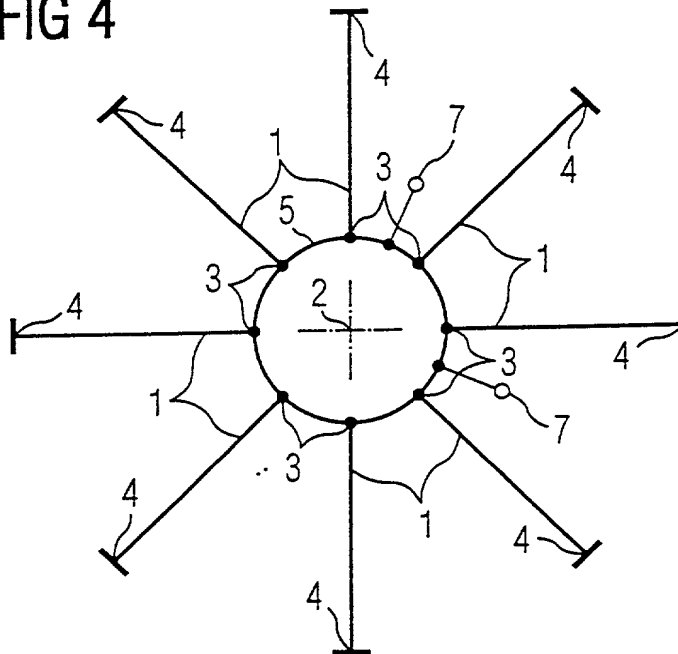


FIG 5

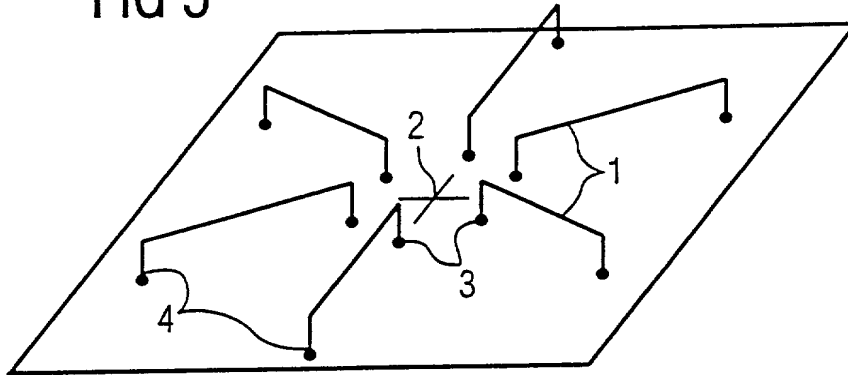


FIG 6

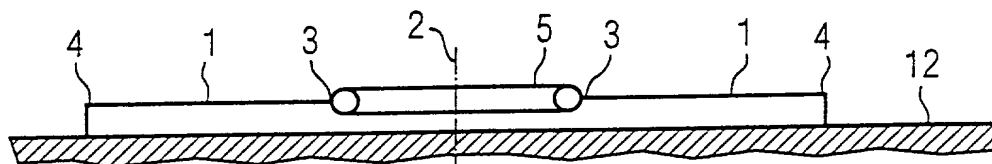
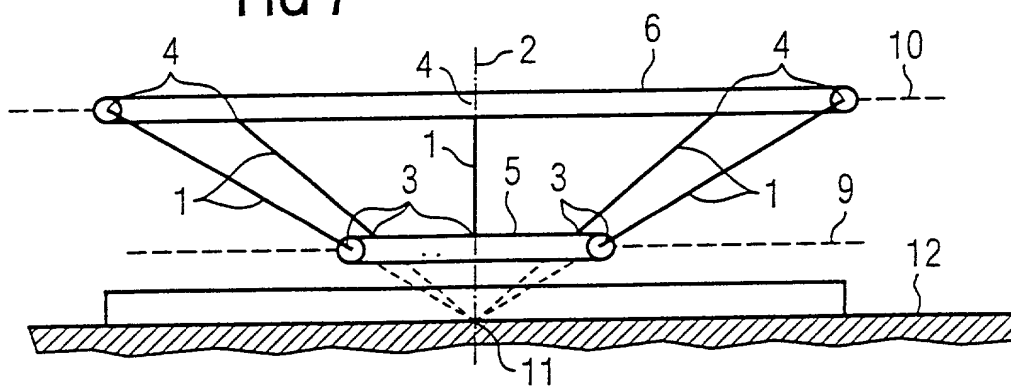


FIG 7



DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

"MAGNETIC RESONANCE ANTENNA"

Case No. P00,0514, the specification of which

(check one) ☒ is attached hereto.
☐ was filed on _____, as
Application Serial No. _____
and was amended on _____
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent Office all information which is known to me to be material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, 1.56.¹

I do not know and do not believe this invention was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, and I believe that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months prior to this application, and that no application for patent or inventor's certificate on this invention has been filed in any country foreign to the United States of America prior to this application by me or my legal representatives or assigns, except as identified below:

I hereby claim foreign priority benefits under Title 35, United States Code, 119 of any foreign application(s) for patent or inventor's certificate listed below

Prior Foreign Application(s) Number	Country	Date
19914989.5	Fed. Rep. Germany	April 1, 1999

and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the above listed application on which priority is claimed:

Prior Foreign Application(s) Number	Country	Date
--	---------	------

¹ (b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

- (1) It establishes, by itself or in combination with other information, a *prima facie* case of unpatentability of a claim; or
- (2) It refutes, or is inconsistent with, a position the applicant takes in:
 - (i) Opposing an argument of unpatentability relied on by the Office, or
 - (ii) Asserting an argument of patentability.

A *prima facie* case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

If no priority is claimed, I have identified all foreign patent applications filed prior to this application:
Prior Foreign Application(s)
Number Country Date

And I hereby appoint Messrs. John D. Simpson (Registration No. 19,842), Dennis A. Gross (24,410), Robert M. Barrett, (30,142), Steven H. Noll (28,982), Kevin W. Gynn (29,927), Robert M. Ward (26,517), Brett A. Valiquet (27,841), Edward A. Lehman (22,312), David R. Metzger (32,919), Todd S. Parkhurst (26,494), James D. Hobart (24,149), Melvin A. Robinson (31,870), Joseph P. Reagen (35,332), Michael R. Hull (35,902), Michael S. Leonard (37,557), William E. Vaughan (39,056), and Lewis T. Steadman (17,074) all members of the firm of Hill & Simpson, A Professional Corporation

Telephone 312/876-0200 Ext. 3491

my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith and direct that all correspondence be forwarded to:

Hill & Simpson
A Professional Corporation
85th Floor Sears Tower, Chicago, Illinois 60606

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor **WOLFGANG RENZ**

Inventor's signature Wolfgang Renz Date 3-27-00
Residence Erlangen, Germany
Citizenship Germany
Post Office Address Wilhelmstr. 15
91054 Erlangen, Germany

Full name of second joint inventor,
(if any)

MARKUS VESTER

Inventor's signature Markus Vester Date 3-27-00
Residence Nuernberg, Germany
Citizenship Germany
Post Office Address Hans-Fallada-Str. 59
90471 Nuernberg, Germany

Full name of third joint inventor,
(if any)

Inventor's signature _____ Date _____
Residence _____
Citizenship _____
Post Office Address _____